
MYCOTAXON

ISSN (print) 0093-4666 (online) 2154-8889 © 2016. Mycotaxon, Ltd.

July–September 2016—Volume 131, pp. 511–520

<http://dx.doi.org/10.5248/131.511>

New records of myxomycetes from México

MARCOS LIZÁRRAGA¹, GABRIEL MORENO^{2*} & MARTÍN ESQUEDA³

¹ Dpto. Ciencias Químico Biológicas, Instituto de Ciencias Biomédicas,
Univ. Autónoma de Ciudad Juárez, Anillo Envoltente Pronaf y Estocolmo s/n,
Ciudad Juárez, Chihuahua 32300, México

² Dpto. Ciencias de la Vida, Edificio de Biología, Univ. Alcalá,
28805 Madrid, Spain

³ Centro de Investigación en Alimentación y Desarrollo,
A.C. Apartado Postal 1735, Hermosillo, Sonora, México

* CORRESPONDENCE TO: gabriel.moreno@uah.es

ABSTRACT—*Badhamia rhytidosperra*, *Didymium synsporon*, *Echinostelium coelocephalum*, *Perichaena polygonospora*, and *Physarum synsporum* are described in both macroscopic and microscopic detail and represent new records from Mexico.

KEY WORDS—*Amoebozoa*, chorology, myxobiota, slime moulds, taxonomy

Introduction

The present paper represents a contribution to a program of study on myxomycetes in Mexico that began 19 years ago and from which several publications have been generated. Most of the latter have been compiled into Mexico's myxomycete inventory by Moreno et al. (2007). In this paper, we present new records of several species that are poorly known worldwide and thus are scarcely referenced in the specialized literature regarding this group of organisms.

Materials & methods

The studied material was obtained from bark samples collected from living trees in several Mexican states (Chihuahua, Mexico City, and Sinaloa) and placed in more than 200 moist chambers. Only species identified as new records for the Mexican myxobiota are reported here.

SPORES (including surface structures such as spines or warts) were measured with an oil immersion lens. Light microscopy (LM) was carried out with a Nikon microscope equipped with an automatic photographic system. SEM micrographs were produced with a Zeiss DSM-950 microscope. For ultramicroscopic studies, material was rehydrated in concentrated (28–30%) ammonium hydroxide for 30 min, dehydrated in aqueous ethanol (70%) for 30 min, fixed for 2 h in pure ethylene glycol dimethyl ether (= 1,2-dimethoxymethane), and finally immersed in pure acetone for at least 2 h. This was followed by critical point drying and sputtering with gold-palladium. This technique allows the use of very little material (i.e., part of a single sporocarp or sometimes no more than a few spores).

Specimens are conserved in the herbarium of the Life Sciences Department (Botany), University of Alcalá, Madrid, Spain (AH) with a duplicate of some specimens deposited in the Fungi Collection of Biomedical Sciences Institute, Autonomous University of Ciudad Juárez, México (UACJ). Permanent slides were prepared with Hoyer's liquid for microscopic study.

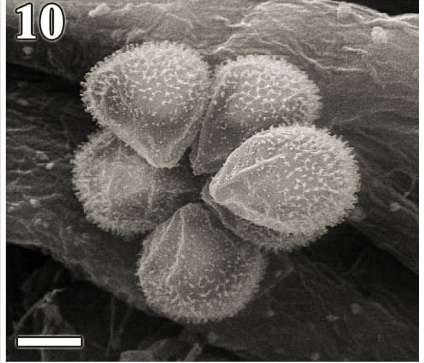
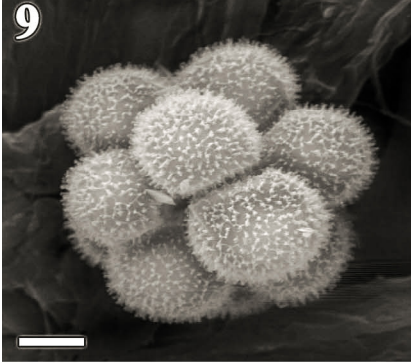
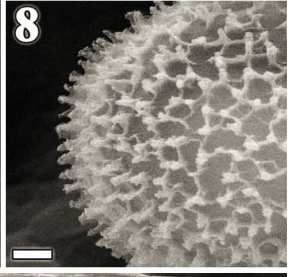
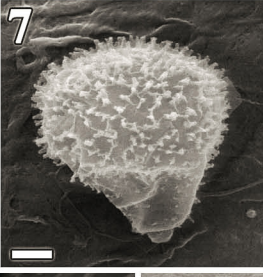
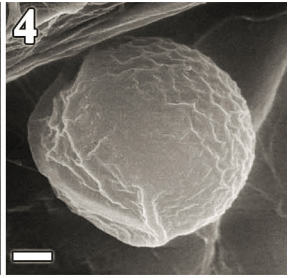
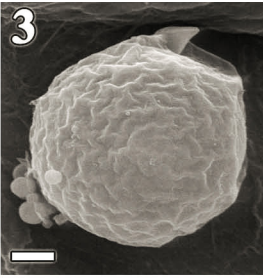
Taxonomy

Badhamia rhytidosperma H.W. Keller & Schokn., Mycologia 81: 783 (1989) Figs 1–4

FRUCTIFICATIONS sessile white plasmodiocarps. SPOROTHECA globose, subglobose to lobular with gyrose-confluent irregular lobes of 0.4–0.6 × 0.7–1.0 mm. PERIDIUM double, calcareous external layer smooth to slightly rough, internal layer membranous with irregular dehiscence. HYPOTHALLUS inconspicuous. CAPILLITIUM physaroid or more rarely badhamioid, formed by joined filaments through elongated to irregular calcareous nodules. When the capillitium is badhamioid a pseudocolumella appears at the center of sporotheca, which is thick, irregular and calcareous. SPORES (10–)12–14(–15) µm diam., black in mass and violaceous under LM, globose to subglobose, surface smooth over one half of the spore but markedly reticulate over the other half. Under SEM a reticulate ornamentation is confirmed in one side and smooth on the opposite side with a distinct ridge or additional lines as indicated by Keller & Schoknecht (1989).

SPECIMEN EXAMINED: MEXICO, CHIHUAHUA: Biomedical Sciences Institute gardens, Autonomous University of Ciudad Juárez, on bark of *Morus nigra* L., 5 February

FIGS 1–13. *Badhamia rhytidosperma* (AH 45861). 1, 2. Plasmodiocarps. 3. Spore showing the reticulate wall as observed by SEM. 4. Spore showing a smooth area with adjacent ridge by SEM. *Didymium synsporon* (AH 45866). 5. Sporocarp. 6. Plasmodiocarp. 7. Spore with bacula outside and smooth inside by SEM. 8. Details of bacula with a verrucose apex and reticulate base by SEM. 9. Spore cluster by SEM. 10. Detail inside a spore cluster by SEM. *Echinostelium coelocephalum* (AH 45867). 11. Spore-like body with thick articulate surfaces. 12, 13. Spores with thick articulate surfaces and regular thickness at contact points between spores. Scale bars: 1, 2, 5, 6 = 0.5 mm; 3, 4, 7 = 2 mm; 8 = 1 µm; 9, 10 = 5 µm.



2000, leg. M. Lizárraga; obtained from moist chamber 21 February 2000 (UACJ 190, AH 45861).

ADDITIONAL SPECIMEN EXAMINED: *Badhamia spinispora*: MEXICO, SONORA: El Pinacate y Gran Desierto de Altar biosphere reserve, on bark of *Parkinsonia* sp., 18 February 2012, leg. M. Lizárraga; obtained from moist chamber 16 March 2012 (AH 45862).

HABITAT & DISTRIBUTION—*Badhamia rhytidosperma* has been described previously from two field collections on alfalfa remnants from the type locality (Kansas, USA) and from moist chamber cultures prepared with cow dung (Keller & Schoknecht 1989). The specimen (AH 45862) from Sonora, Mexico, recorded originally as *B. rhytidosperma* by Esqueda et al. (2013) is here redetermined as *B. spinispora*. Consequently our Chihuahua specimen represents the first authentic Mexican record of *B. rhytidosperma*.

OBSERVATIONS—*BADHAMIA RHYTIDOSPERMA* is morphologically similar to *Badhamia spinispora* (Eliasson & N. Lundq.) H.W. Keller & Schokn., *B. verrucospora* G. Moreno et al., and *Physarum apiculosporum* Härk. from which it is clearly distinguished by its spore ornamentation. Spores are spiny in *B. spinispora*, verrucose in *B. verrucospora*, and smooth in *P. apiculosporum* (Moreno et al. 2011), whereas *Badhamia rhytidosperma* has globose spores in which half of the spore is smooth and the other is reticulate. On its surface, a crested conspicuous line is observed at the site where the spore germinates (FIG 4). Based on the literature, only the type material described by Keller & Schoknecht (1989) was previously known.

Didymium synsporon T.E. Brooks & H.W. Keller, Mycologia 65: 287 (1973)

FIGS 5–10

FRUCTIFICATIONS sessile, sporocarpic, or (more rarely) plasmodiocarpic, ranging from pulvinate to flat and occasionally umbilicate, 0.3–1 × 0.1–0.8 mm, whitish to grey-white. **PERIDIUM** formed by two joined layers, the external layer crust-like (similar to an eggshell) and the inner layer membranous and translucent. A columella was not observed. **CAPILLITIUM** is formed by rigid and parallel filaments arising from the sporocarp base towards its apex; the ends are dichotomous or bifurcate with few transversal junctions, dark to hyaline at apex of 1–3(–4) µm diam. and few enlargements. **SPORES** dark in mass and violaceous under LM, in clusters of 8–20, 10–12 µm diam., pyriform to subglobose, conspicuous ornamentation formed by fused warts that provide a reticular to subreticular aspect, the ornamentation becoming less dense (formed of small sparse warts) toward the base where attached to other spores. Under SEM, the spore ornamentation is formed by bacula with a verrucose apex and reticulate base.

SPECIMENS EXAMINED: MEXICO, CHIHUAHUA: Cumbres de Majalca, on bark of *Juniperus* sp., 22 September 2003, leg. M. Lizárraga; obtained from moist chamber 29 September 2003 (UACJ 493); obtained from moist chamber 30 September 2003 (UACJ 466); obtained from moist chamber 1 October 2003 (UACJ 504, AH 45865); obtained from moist chamber 8 October 2003 (UACJ 470); 8 August 2014, leg. M. Lizárraga; obtained from moist chamber 14 August 2014 (AH 45866).

HABITAT & DISTRIBUTION—*Didymium synsporon* was first described in the United States from bark sampled from living *Juniperus virginiana* L., cultured in moist chambers, and there are limited records in the United States (Arkansas, Kansas, Kentucky, and Tennessee; Keller & Brooks 1973). The species was also observed from a collection made on *Opuntia* sp. from Atacama, Chile (Lado et al. 2007).

OBSERVATIONS—This species is distinguished by its crust-like external peridium, spore clusters, and a capillitium formed by rigid parallel filaments rising from the sporocarp base towards the apex. It is the only known *Didymium* species with clustered spores.

Echinostelium coelocephalum T.E. Brooks & H.W. Keller, Mycologia 68: 1212

(1977) ["1976"].

FIGS 11–13

SPOROCARPS isolated to gregarious, stipitate, 45–60 µm total height, whitish to slightly yellow. Stipe 20–30 µm long, cylindrical and expanded towards the base to 4–6 µm diam., becoming thinner towards the apex of 1–1.5 µm diam. SPOROTHECA globose to subglobose, 20–30 µm diam., white to slightly yellow. CAPILLITIUM absent. PERIDIUM persistent, similar to a thick collar at columella base of 5–8 µm diam. SPORES hyaline in mass and whitish to yellowish under LM, globose to subglobose, 7–10 µm diam., faintly verrucose with thick articulate surfaces and regular thickness, c. 1 µm thick at contact point between spores.

SPECIMEN EXAMINED: MEXICO, CHIHUAHUA: Cumbres de Majalca, on bark of *Quercus* sp., 15 November 2003, leg. M. Lizárraga & G. Mendoza; obtained from moist chamber 6 May 2004 (UACJ 605, AH 45867).

HABITAT & DISTRIBUTION—*Echinostelium coelocephalum* was described from Arkansas in the United States from bark samples collected in different American states and cultured in moist chambers (Keller & Brooks 1977). It has since been reported from Argentina (Lado et al. 2014), Australia (Davison et al. 2008), Belize (Lado et al. 2008), France (Mitchell et al. 1984), New Caledonia (Kylin et al. 2013), the Republic of South Africa (Ndiritu et al. 2009), Spain (Pando 1989), U.S.A. (Haskins et al. 2000), and Kazakhstan, Ukraine, Tunisia, and Turkey (Discover Life 2015). It is possibly an extensively distributed species that has been overlooked because of its small size and resemblance to other similar species.

OBSERVATIONS—Characterized by its small size and articulate spores with evenly thick walls, *E. coelocephalum* may be confused with *E. colliculosum* K.D. Whitney & H.W. Keller, which differs by its larger fructifications (70–150 µm) and spores with narrow articulations. Haskins & McGuinness (1986) examined the microwarts on the spore surface of *E. coelocephalum* under the SEM, and Haskins et al. (2000) investigated heterothallic mating systems in this species.

Perichaena polygonospora Novozh., Zeml., Schnittler & S.L. Stephenson, Mycologia 100: 819 (2008) FIGS 14–19

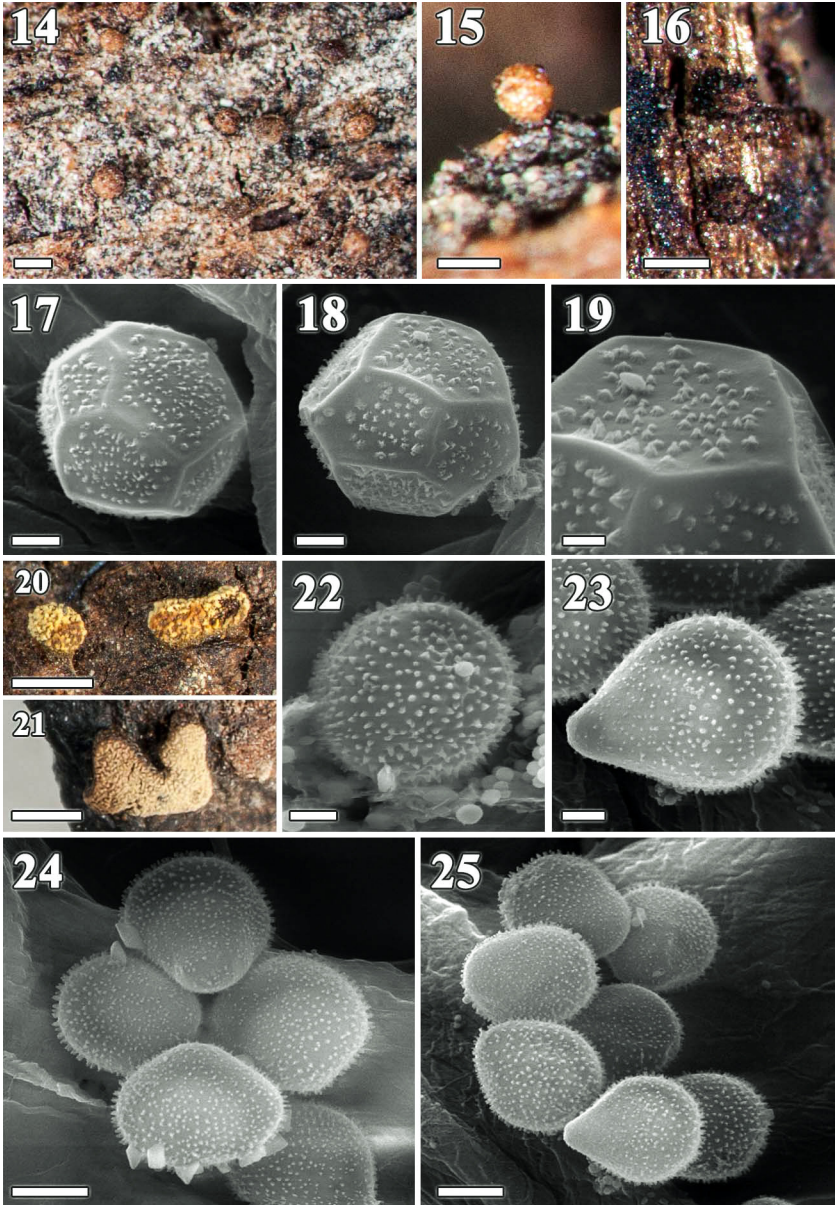
SPOROCARPS sessile, isolated to gregarious. SPOROTHECA very small, 0.1–0.15 mm diam., globose to subglobose, yellow-orange to dark yellow. PERIDIUM simple and membranous, frequently appearing as externally ornamented with dark-brown small protrusions or warts homogenously distributed on its surface and composed of granulated material; inner surface smooth under LM. Dehiscence irregular. CAPILLITIUM absent. SPORES yellowish in mass and bright yellow under LM, (10–)11–12(–13) µm diam., globose to subglobose, polyhedral, verrucose. The polyhedral morphology of the verrucose spores and its well-defined smooth angles were confirmed under SEM. Spore ornamentation consists of fused bacula that form pyramidal structures of different sizes and thickness.

SPECIMENS EXAMINED: MEXICO, MEXICO CITY: Bosque de Chapultepec, on bark of *Taxodium mucronatum* Ten., 30 March 2015, leg. M. Lizárraga; obtained from moist chamber 16 May 2015 (AH 45868); obtained from moist chamber 3 June 2015 (AH 45869); obtained from moist chamber 11 June 2015 (AH 45870).

HABITAT & DISTRIBUTION—*Perichaena polygonospora* fruits on litter and small twigs of shrubs but also on weathered herbivore dung (Novozhilov et al. 2008). Studied specimens were collected from New Mexico (United States) on elk dung (*Cervus canadensis*) (Mitchell & Moreno 2013) from Mexico City on bark of *Taxodium mucronatum*. This species was originally described in Russia and Kazakhstan by Novozhilov et al. (2008) and recorded and described later in the United States by Mitchell & Moreno (2013).

OBSERVATIONS—*Perichaena polygonospora* is characterized by its minute (0.1–0.15 mm diam) globose sporotheca, generally with dark brown protrusions attached to the peridium, irregular dehiscence, polyhedral spores, and lack of a capillitium. A similar species, *Licea eremophila* D. Wrigley et al., also has similarly sized [(9–)10–12(–13) µm diam] polyhedral spores but can

FIGS 14–25. *Perichaena polygonospora* (AH 45870, except for FIGS 14, 15). 14. Gregarious sporocarps (AH 45557). 15. Sporocarp detail (AH 45557). 16. Peridium with small warts dark-brown. 17, 18. Polyhedral spores by SEM. 19. Detail of spore ornamentation by SEM. *Physarum snyderi* (AH 45557, except for FIG. 20). 20. Fructifications sporangiate to plasmodiocarpic



(AH 45872). 21. Branched sporotheca. 22. Spore with bacula on the outside by SEM. 23. Spore with bacula on the outside and smooth on the inner surface by SEM. 24. Spore cluster by SEM. 25. Detail of an internal spore cluster by SEM. Scale bars: 14–16 = 100 μ m; 17, 18, 22, 23 = 2 μ m; 19 = 1 μ m; 20, 21 = 0.5 mm; 24, 25 = 5 μ m.

be distinguished by its stipitate sporotheca, a peridium formed by plates, and its habitat on dead leaf bases of the bromeliad *Puya* spp. and dead remains of the cacti *Trichocereus* sp. and *Miqueliopuntia miquelii* (Monv.) F. Ritter from Argentina and Chile (Wrigley de Basanta et al. 2010).

Perichaena polygonospora belongs to the *Perichaena* group that lacks a capillitium and includes such species as *P. pachyderma* D.W. Mitchell et al., which also fruits on herbivore dung (deer, elk, and cow) but differs by its globose, verrucose, non-polyhedral spores (10–11(–12) μ m diam.; Mitchell et al. 2011).

Physarum synsporum S.L. Stephenson & Nann.-Bremek., Proc. Kon. Ned. Akad.

Wetensch., C. 93:193 (1990)

FIGS 20–25

FRUCTIFICATIONS solitary to gregarious, sporangiate to plasmodiocarpic, sessile. SPOROTHECA subglobose, flat and somewhat branched, 0.3–1.5 $\times$ 0.3–0.5 mm, yellowish to grey-yellowish. PERIDIUM simple and calcareous, superficially granulated due to calcium carbonate nodules lifting the peridium. Dehiscence irregular. CAPILLITIUM formed by a calcareous nodule network that ranges from subglobose to fusiform, whitish and joined by small hyaline filaments. SPORES dark brown in mass and violaceous brown under LM, 10–12 μ m diam., in clusters consisting of 4–8 pyriform, turbinate to subglobose spores that are easily dispersed; the surface superficially verrucose on the spore base but becoming less dense (small sparse warts) closer to the attachment zone with the next spore. SEM confirms the turbinate morphology and reveals an ornamentation composed of abundant bacula outside but very scarce and smaller to almost absent inside. No plasmodium was observed.

SPECIMENS EXAMINED: MEXICO, SINALOA: Culiacán, Colonia Guadalupe Victoria, on bark of *Mangifera indica* L., 20 February 2013, leg. M. Lizárraga; obtained from moist chamber 5 September 2014 (AH 45871); obtained from moist chamber 1 October 2014 (AH 45872).

HABITAT & DISTRIBUTION—*Physarum synsporum* was described in the United States based on material appearing on samples of *Juniperus virginiana* in a moist chamber. Subsequently, it has been reported only on shrub twigs in Argentina (Lado et al. 2011).

OBSERVATIONS—The diagnostic characters of *P. synsporum* are the plasmodiocarpic to sporocarpic fructifications with a yellowish and strongly granulated peridium as well as clustered spores, which are easily dispersed, allowing the observation of its pyriform or turbinate shapes with their marked ornamentation at the external portion of the spore.

Physarum lakhanpalii Nann.-Bremek. & Y. Yamam., a species difficult to characterize, is distinguished by its plasmodiocarpic yellowish fructifications,

yellow carbonate calcium nodules, and subglobose (11–12.5 µm diam.) densely verrucose spores in clusters of 4–6 (Nannenga-Bremekamp & Yamamoto 1987); because the protologue does not indicate the distribution of the verrucae, we assume that they are homogeneously distributed all along the edge of the spore.

Shortly after the publication of *P. lakhanpalii*, a second species with clustered spores (*P. synsporum*) was described that is characterized by dark-brown plasmodiocarpic fructifications, whitish calcium carbonate nodules, and clusters of 3–8 subglobose to turbinate spores (12–13 µm diam), smooth or displaying few small warts on the inside (Stephenson & Nannenga-Bremekamp 1990). These authors separate *P. synsporum* from *P. lakhanpalii* by its capillitium with whitish nodules and its turbinate spore clusters with warts obvious only on the external area.

The specimens from Mexico correlate well microscopically with the description of *P. synsporum*, although the fructification has a yellowish color instead of dark-brown as originally described. According to our experience, as this species was obtained from a moist chamber, it probably did not optimally develop the peridium pigmentation. *Physarum decipiens* M.A. Curtis is very similar to *P. synsporum*, differing only in the absence of clustered spores.

Acknowledgements

We wish to express our gratitude to Mr. A. Priego and Mr. J. A. Pérez of the Electron Microscopy Service of the University of Alcalá de Henares for their invaluable help with the SEM. We also thank L. Monje and A. Pueblas of the Department of Drawing and Scientific Photography at the Alcalá University for their help in the digital preparation of photographs and to Dr. J. Rejos, curator of the AH herbarium for his assistance with the specimens examined in the present study. We want to express our gratitude to S.L. Stephenson and J.R. Deschamps for reviewing the manuscript. M. Lizárraga extends thanks to Dr. Alejandro Martínez of Dpto. Ciencias Químico Biológicas, Universidad Autónoma de Ciudad Juárez, for economic support.

Literature cited

- Davison EM, Davison PJN, Brims MH. 2008. Moist chamber and field collections of myxomycetes from the northern Simpson Desert, Australia. *Australasian Mycologist* 27: 129–135.
- Discover Life. 2015. <http://www.discoverlife.org/> [accessed 1.XII.2015].
- Esqueda M, Coronado ML, Gutiérrez A, Lizárraga M, Raymundo T, Valenzuela R. 2013. Hongos de reserva de la biosfera El Pinacate y Gran Desierto de Altar. CIAD. Hermosillo, Sonora, México. 107 p.
- Haskins EF, McGuinness MD. 1986. Comparative ultrastructural observations of spore wall structure in six species of *Echinostelium* and three species of *Eumycetozoa*. *Mycologia* 78: 613–618. <http://dx.doi.org/10.2307/3807774>
- Haskins EF, McGuinness MD, Clark J. 2000. Heterothallic mating systems in the *Echinosteliales* II. *Echinostelium coelocephalum*. *Mycologia* 92: 1080–1084. <http://dx.doi.org/10.2307/3761475>

- Keller HW, Brooks TE. 1973. Corticolous myxomycetes I: two new species of *Didymium*. *Mycologia* 65: 286–294. <http://dx.doi.org/10.2307/3758101>
- Keller HW, Brooks TE. 1977 [“1976”]. Corticolous myxomycetes V: observations on the genus *Echinostelium*. *Mycologia* 68: 1204–1220. <http://dx.doi.org/10.2307/3758753>
- Keller HW, Schoknecht JD. 1989. Spore-to-spore cultivation of a new wrinkled-reticulate-spored *Badhamia*. *Mycologia* 81: 783–789. <http://dx.doi.org/10.2307/3759883>
- Kylin H, Mitchell DW, Seraoui El-H, Buyck B. 2013. Myxomycetes from Papua New Guinea and New Caledonia. *Fungal Diversity* 59: 33–44. <http://dx.doi.org/10.1007/s13225-012-0180-y>
- Lado C, Estrada-Torres A, Stephenson SL. 2007. Myxomycetes collected in the first phase of a north-south transect of Chile. *Fungal Diversity* 25: 81–101.
- Lado C, Wrigley de Basanta D. 2008. A review of neotropical myxomycetes (1828–2008). *Anales del Jardín Botánico de Madrid* 65(2): 211–254. <http://dx.doi.org/10.3989/ajbm.2008.v65.i2.293>
- Lado C, Wrigley de Basanta D, Estrada Torres A. 2011. Biodiversity of myxomycetes from the Monte Desert of Argentina. *Anales del Jardín Botánico de Madrid* 68: 61–95. <http://dx.doi.org/10.3989/ajbm.2266>
- Lado C, Wrigley de Basanta D, Estrada-Torres A, García-Carvajal E. 2014. Myxomycete diversity of the Patagonian Steppe and bordering areas in Argentina. *Anales del Jardín Botánico de Madrid* 71(1): e006. <http://dx.doi.org/10.3989/ajbm.2394>
- Mitchell DW, Moreno G. 2013. A species of *Perichaena* new to North America. *Boletín Sociedad Micológica de Madrid* 37: 73–76.
- Mitchell DW, Nannenga-Bremekamp NE, Champion CL, Clark MC. 1984. *Myxomycota* ramassés en France et conserves dans nos collections privées. *Documents Mycologiques* 14(54–55): 51–60.
- Mitchell DW, Moreno G, Lizárraga M. 2011. A new species of coprophilous *Perichaena* from New Mexico. *Boletín de la Sociedad Micológica de Madrid* 35: 103–108.
- Moreno G, Lizárraga M, Illana C. 2007. Catálogo de los myxomycetes de México. *Boletín Sociedad Micológica de Madrid* 31: 187–229.
- Moreno G, Mitchell DW, Novozhilov YK. 2011. A new species of *Badhamia* (myxomycetes) confused with other species with similar morphology. *Boletín de la Sociedad Micológica de Madrid* 35: 95–102.
- Nannenga-Bremekamp NE, Yamamoto Y. 1987. Additions to the myxomycetes of Japan III. *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen. Series C, Biological and Medical Sciences* 90: 311–349.
- Ndiritu GG, Winsett KE, Spiegel FW, Stephenson SL. 2009. A checklist of African myxomycetes. http://www.mycotaxon.com/resources/checklists/ndiritu_v107-checklist.pdf [Summary in *Mycotaxon* 107: 353–356. <http://dx.doi.org/10.5248/107.353>]
- Novozhilov YK, Zemlyanskaya IV, Schnittler M, Stephenson SL. 2008. Two new species of *Perichaena* (myxomycetes) from arid areas of Russia and Kazakhstan. *Mycologia* 100: 816–822. <http://dx.doi.org/10.3852/08-047>
- Pando F. 1989. Un estudio sobre los myxomycetes corticícolas de la isla de Mallorca. *Anales del Jardín Botánico de Madrid* 46(1): 181–188.
- Stephenson SL, Nannenga-Bremekamp NE. 1990. Five new species of myxomycetes from North America. *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen. Series C, Biological and Medical Sciences* 93: 187–195.
- Wrigley de Basanta D, Lado C, Estrada-Torres A. 2010. *Licea eremophila*, a new myxomycete from arid areas of South America. *Mycologia* 102: 1185–1192. <http://dx.doi.org/10.3852/09-309>.